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Silane as pretreatment for protection of steel

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Abstract

Steel has been used as structural material for ages although it interacts with the environment loosing its main important property. The aim of this research was to study different times of silane hydrolysis in order to obtain better anticorrosive protection of steel. The substrates employed were sandblasted steel and sandblasted steel exposed to the salt spray chamber in order to oxidize the substrate and evaluate the performance of the silane on a not-so-well prepared surface. Electrochemical tests such as polarization curves and corrosion potential measurements were done on the pretreated metal. Results showed the silane film protect steel even when the surface preparation was not adequate.

Introduction

Silanes applied on different substrates by the sol-gel technique had been used as protectors of the surfaces. The application of silanes films on metal can be done taking into account variables such as pH and silane concentration of the solution and hydrolysis time, curing conditions, additions of dopants [1-3], etc. The selection of these variables is important as the final characteristics of the films depend on them [4]. Moreover, silanes can be selected to interact with the substrate as well as with the resin of a coating in case it is of interest to paint it as an extra protection.

The aim of this work was to study steel protection employing a mercaptopropyltrimethoxy-silane (MTMO) film. The silane formula is $[HS(CH_2)_3Si(OCH_3)_3]$. As substrates sandblasted steel and sandblasted steel exposed 4 hours in the salt spray chamber were employed. The silane was hydrolyzed different times in a methanol/distilled water solution to study the hydrolysis time effect and the surface preparation on the film protective action. Electrochemical tests were done on treated and untreated substrates.

Experimental

The silane solution was prepared dissolving MTMO in methanol/distilled water at pH = 4 and stirred for 1, 48 and 72 hours. After the hydrolysis period, the solution was diluted with the same methanol/water solution up to a final concentration of 4% (clean substrate) or 16% (oxidized substrate) [4]. Then antiflash rusting and wetting agents were added.

Steel panels were sandblasted and some of them exposed in the salt spray cabinet for 4 hours in order to oxidize the substrate. After exposure, these panels were cleaned with a steel brush and finally with Nº 150 abrasive emery paper.

The substrates were immersed in the final silane solution and cured 10 minutes at 80ºC.
The surface of the panels was observed by scanning electron microscopy (SEM) and the composition of the films was studied by energy dispersive X-ray analysis (EDXA).
Polarization curves (Tafel mode and lineal polarization) and corrosion potential were employed to study the anticorrosive performance of the films. Polarization curves were done employing a three-electrode cell while corrosion potential was measured employing a saturated calomel electrode as reference electrode. The electrochemical tests were done on steel with and without pre-treatment after a certain time of immersion in NaCl solution.

Results and Discussion

The observation of the treated surface showed the silane film formed on the steel is heterogeneous. The composition of these films indicated that some S atoms were lost and that cross linking has occurred during curing.
Tafel curves showed that the corrosion current (I) was shifted to lesser values when the pre-treatment was applied. Moreover, in the case of the oxidized substrate, these values were independently of the hydrolysis time.
The corrosion potential (E) values were depleted to slightly more positive ones comparing untreated with treated non-oxidized steel while the corrosion potential of the untreated and treated oxidized substrate were similar.
The polarization resistance values showed there is not a barrier protection as the values with (Rp*) and without IR-compensation (Rp) were similar.
Table 1 shows the electrochemical test results.

Hydrolysis time / substrate	Rp (kΩ.cm^2)		Rp* (kΩ.cm^2)		E (mV)		I (μA.cm^{-2})
	2h	24h	2h	24h	2h	24h	2h
1h / s	15.2	---	12.2	---	-487	---	52.1
48h / s	9.6	1.1	5.8	0.9	-481	-607	9.9
72h / s	60.0	3.8	38.8	2.9	-503	-511	11.2
sandblasted	0.4	---	0.3	---	-623	---	226.8
1h / o	76.3	7.4	23.8	3.9	-636	-546	2.0
48h /o	8.6	2.7	6.2	1.4	-522	-535	2.0
72h / o	5.7	3.4	1.2	1.7	-536	-528	1.3
oxidized	0.6	0.2	0.1	0.02	-428	-634	74

Table 1. Results of the electrochemical tests. s: sandblasted, o: sandblasted oxidized in salt spray chamber

Conclusions

Taking into account the results mercaptopropyltrimethoxysilane can be used to protect steel from corrosion even when the surface preparation was not good.

References

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